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CFD MODELING OF THE IRIS DOWNCOMER IN SUPPORT TO THE DESIGN OPTIMIZATION

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Abstract

This work is part of the thermo-hydraulic analyses that constitute the contribution of the University of Pisa to the international IRIS project. The aim of the present activity is to study, through the use of Computational Fluid Dynamics (CFD) codes, the flow inside the downcomer of the reactor. Identified the most relevant phenomena for the considered flow (single jet spreading, mixing of parallel jets and influence of confined domain), it was necessary to evaluate the capability of some commercial codes – CFX, STAR-CD, STAR-CCM+ and FLUENT – in correctly reproducing them. Therefore, experimental data concerning the single free jet and parallel confined jets were selected from the available literature. Owing to the obtained insight into phenomena, the simulation of the downcomer fluid flow was performed. Finally, basing on the obtained information some design modifications were proposed, aiming to the optimization of the flow structure in the downcomer; the performed simulations highlighted the capability of the proposed solutions in promoting the uniformity of the outlet velocities, while decreasing the pressure drop.

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to my parents

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List of Symbols

Latin letters

A	area [m^2];
C_p	pressure-recovery coefficient;
g	gravity [m/s^2];
p	pressure [Pa];
R	radius [m];
T	temperature [K];
T	time [s];
u	velocity component along the x axis [m/s];
v	velocity component along the y axis [m/s];
w	velocity component along the z axis [m/s];
W	width of a diffuser throat [m];

Greek letters

ρ	density [kg m^{-3}];
ζ	fiction factor;
μ	dynamic viscosity [kg/(m s)];
ϑ	divergence angle of a diffuser [degree];
k	turbulent kinetic energy [m^2/s^2];
ε	dissipation rate of turbulent kinetic energy [m^2/s^3];

Acronyms

ASME	American Society of Mechanical Engineers;
CFD	Computational Fluid Dynamics;
CRDM	Control Rod Drive Mechanism;
CV	Containment Vessel;
DIMNP	Dipartimento di Ingegneria Meccanica, Nucleare e della Produzione;
DOE	Department Of Energy;
IRIS	International Reactor Innovative and Secure;
GIF	Generation IV International Forum;
MARS	Monotone Advection and Reconstruction Scheme;

MIT	Massachusetts Institute of Technology;
NERI	Nuclear Energy Research Initiative;
LOCA	Loss Of Coolant Accident;
LOFA	Loss Of Flow Accident;
LWR	Light Water Reactor;
PIRT	Phenomena Identification and Ranking Table;
PWR	Pressurized Water Reactor;
RV	Reactor Vessel;
SG	Steam Generator;
SST	Shear Stress Transport.